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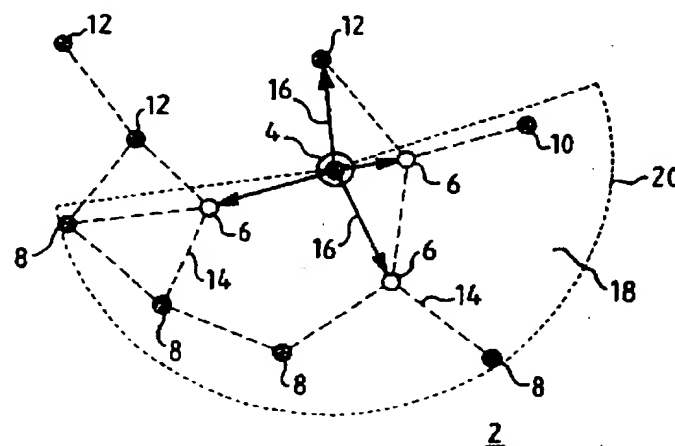
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(54) Abstract Title

### Message dissemination in a radio communication network

(57) In a method for dissemination of a message in an incomplete radio communications network (2) with a changing number of subscribers (4 to 12) for the passing-on of the message, wherein each subscriber has transmitting and receiving equipment for messages and a positioning system for ascertaining the global position of that subscriber, subscribers (6 to 12) after reception of the message ascertain their own position and the distance to the sender of the message, who is also a subscriber (4), and send the message with their own position after a predetermined waiting time. The waiting time decreases monotonically with increasing distance to further subscribers (6 to 12). This results in a rapid transmission, which does not unduly load the radio communications network (2), of the message.

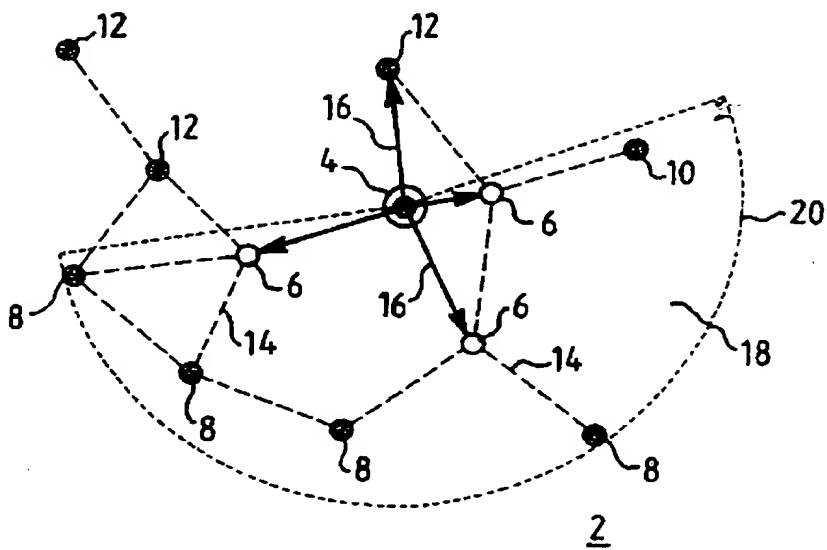
**FIG.1**



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**FIG.1**



**FIG. 2**

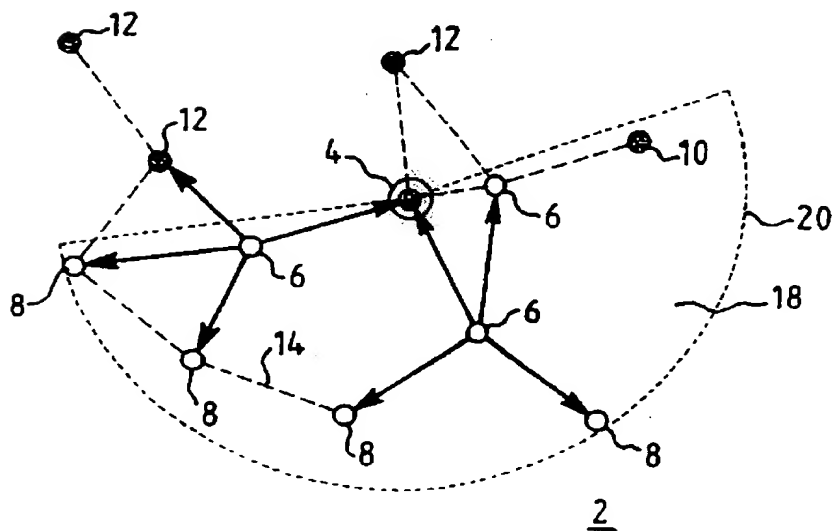


FIG. 3

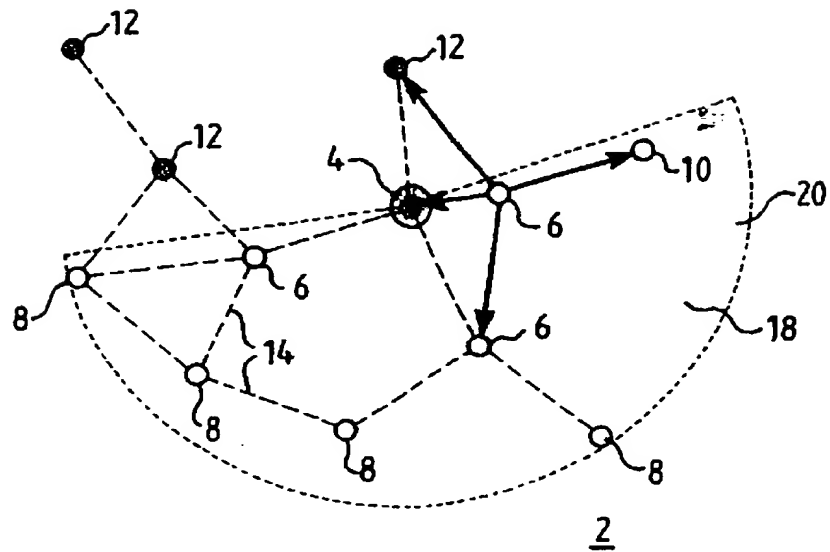
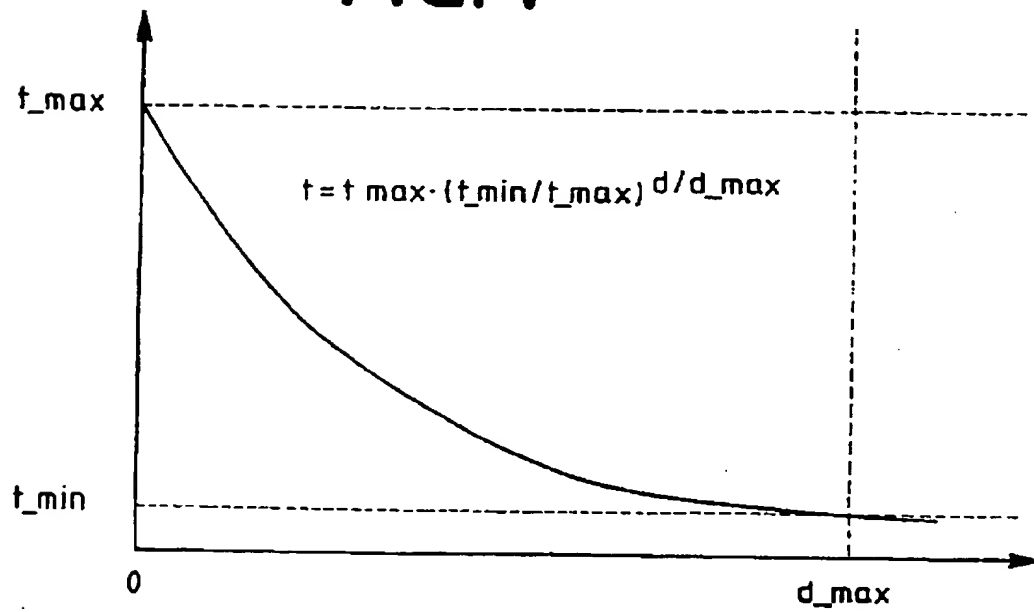


FIG. 4



## MESSAGE DISSEMINATION IN A RADIO COMMUNICATION NETWORK

The present invention relates to a method of disseminating a message in an incomplete radio communications network, and to a radio communications network.

Methods for the dissemination of messages are used in, for example, the field of mobile wireless communication, especially so-called ad hoc networks. In ad hoc networks, mobile subscribers connect together spontaneously and at short notice. The disposition of the subscribers of the network is random and can change in space and time. An ad hoc network is, as a rule, a mobile decentrally controlled radio communications network which is not complete.

A radio network is regarded as complete only when a direct radio connection exists between each subscriber pair. Each subscriber is equipped with a radio equipment so that communication can be carried out with other subscribers within range. There is no central authority which controls or checks the radio network thus formed. Furthermore, the subscribers have local clocks with a uniform time resolution.

Ad hoc networks arise for example when mobile computers (laptops, palmtops and so forth) combine together into a conference. Several robots, which communicate with each other and which move in areas with difficult access, for example in space, underwater, on a battlefield and so forth, can also form an ad hoc network.

There are also miniature devices which have communications possibilities and are carried by persons on the body. Such devices include, for example, a device with the name "Lovegety" of the company Erfolg Co., Japan, which is described inter alia in the Journal "Tagesspiegel" of 3 June 1998 under the heading "Leute" and is provided for the finding of a suitable partner. In future, such devices could also form ad hoc networks in order to solve more complex problems.

Finally, radio-based direct vehicle-to-vehicle communication also comes within this field.

In the case of known methods for the dissemination of messages, the address to which the messages are to be sent must be known by the identified communications partners. If this prerequisite is not fulfilled, the known methods cannot be used, because the required

information can be obtained only with a disproportionately high effort. Moreover, it is frequently presupposed that a direct radio connection exists between each subscriber pair.

In order to bring the known methods into use, the entire network topology must be known or be able to be ascertained by central authorities. The topology of a network is the form of distribution of the subscribers or network nodes and their connection with each other.

There is thus a need for a method for dissemination of a message in an incomplete radio communications network with a changing number of subscribers for the passing-on of the message, in which the message is transferred as rapidly as possible and the subscribers do not necessarily have radio contacts with each other at every point in time.

According to a first aspect of the invention there is provided a method for dissemination of a message in an incomplete radio communications network with a changing number of subscribers for the passing-on of the message, wherein each subscriber has transmitting and receiving equipment for messages as well as a positioning system for ascertaining his global position, wherein subscribers after reception of the message ascertain their own position and distance from the sender of the message, who is also a subscriber, and pass on the message with their position to further subscribers after a predetermined waiting time, wherein the waiting time decreases monotonically with increasing distance.

Such a method ensures an optimum distribution of messages, in particular short messages, data packets and status reports, in a radio communications network when no information about the network topology is available to the subscribers. The message is communicated rapidly by a subscriber, which acts as sender of the message to be transmitted, to at least one further subscriber of the partial network, not all subscribers of which necessarily have to be situated in range of the sender of the message.

By contrast to known methods, a method exemplifying the invention takes into consideration the limited knowledge of individual subscribers in the mobile decentralised radio communications network. The complete topology of the network need not be known to the subscribers. The method optimises the message dissemination, for which purpose only a little knowledge about the subscribers of the network and about the actual network is presupposed.

The presupposition that knowledge of the topology of the network is not necessary for each subscriber is appropriate, since the topology can change constantly due to the high mobility of the subscribers.

A typical example relating to a traffic situation clarifies this, in particular an accident between two motor vehicles on a road. A message about the accident is transmitted into the immediate area by at least one of the motor vehicles, which is involved in the accident, as initiator. The target region for the message encompasses, for example, a target space with a semicircular base area and a radius of approximately 10 kilometres. All motor vehicles situated in this target space form the target group for the message. The position of the receivers as well as the number of the receivers usually change with the time. Therefore, exact knowledge of the network topology within the target space at a certain instant does not give necessary or useful information.

Preferably, the message sent by the first subscriber contains a geometric description of the target region for his message. By fixing the boundary of the target region, it can be clarified from the outset for which circle of receivers the message to be sent results in a message which can be usefully evaluated.

Preferably, the subscribers can decide about their affiliation to the target region with the aid of a decision function and pass on the message only in the case of belonging to the target region. Apart from the geometric boundary of the target region, other decision criteria can also be relevant for a decision whether or not the subscribers belong to the envisaged target region.

For preference, the subscribers pass on the received message only after the first reception of the message. Each subscriber decides, after reception of the message, whether he has received the message for the first time. For this purpose, the subscriber searches a list which contains a message code about an unambiguous association of the previously received messages with the respective sender. If the subscriber has received the message previously, he undertakes no further activities, since he has already passed on the message to further subscribers at an earlier point in time. An unnecessary occupation of the network is thus avoided. Expediently, the message is provided with a counter which indicates the number of the effected messages, wherein the message is passed on so often that a preset value for the counter is reached.

Preferably, the waiting time between reception and transmission decreases exponentially with increasing distance between the communicating subscribers. This control of the waiting time has, in tests, proved to be particularly advantageous.

For preference, the message contains the global position of an event. Expediently, the global position is ascertained by a method forming the basis of the global positioning system. The transmission of the message can take place by an omnidirectional radiator.

According to a second aspect of the invention there is provided a radio communications network comprising respective equipment for message transmission and reception and determination of position accompanying each of a variable number of subscribers, wherein the equipment accompanying each subscriber comprises ascertaining means for ascertaining the position of the subscriber and distance from a subscriber transmitting a message received by that equipment and transmission means for transmitting on the message together with the ascertained position to further subscribers after a predetermined waiting time which decreases monotonically with increasing ascertained distance.

Examples of the method and embodiments of the radio communications network will now be more particularly described with reference to the accompanying drawings, in which:

Figs. 1 to 3 are diagrams illustrating different scenarios for message dissemination by methods exemplifying the invention; and

Fig. 4 is a diagram showing the relationship of waiting time  $t$  for message retransmission in dependence on distance  $d$  between two subscribers to a radio communications network in performance of a method exemplifying the invention.

Referring now to the drawings there is shown in each of Figs. 1 to 3 an incomplete radio communications network 2. A network is denoted incomplete when a direct radio connection does not exist between each two subscribers to the network. The network 2 usually has a changing number of subscribers 4, 6, 8, 10 and 12. Possible direct radio connections between subscribers 4 to 12 are described by dashed lines 14 and arrows 16.



Each subscriber 4 to 12 has transmitting and receiving equipment for messages as well as a positioning system for ascertaining the global position of that subscriber.

Fig. 1 illustrates a scenario in the radio communications network 2 at an instant  $t_1$ , at which a subscriber 4 sends a message into the surrounding space. The global position of the subscriber 4 is also communicated together with a message. The transmission of the message can be effected by, for example, an omnidirectional radiator.

The message, which is sent by the subscriber 4, together with information about the global position of that subscriber is received by subscribers 6. The radio connections which are possible at the instant  $t_1$  with the co-operation of the subscriber 4 are represented by the arrows 16. The message sent by the subscriber 4 contains a description of the target region for his message. Restriction to a target region need not, however, apply in all cases.

In the present situation, four subscribers 6 and 12 can be reached by the first subscriber 4 due to the technical boundary conditions. However, only the subscribers 6 are situated in the predetermined target region 18, which is bounded by the dotted closed line 20.

In a further example, which is not illustrated, no target region is provided, i.e. the subscribers 12 can also receive a message from the subscriber 4.

The subscribers 6 are, for the sake of clarity, illustrated by empty circles.

The illustrated constellation of subscribers could result from, for example, positions in road traffic. The subscriber 4 could then be, for example, a motor vehicle which has come to rest due to an engine breakdown and which obstructs the following road traffic. A message from the stationary subscriber 4 to subscribers 6, i.e. following motor vehicles on the same side of the road, could be provided in order to inform these about the actual engine breakdown of the subscriber 4. Formation of a traffic jam can then be avoided.

Transmission of the corresponding message should ideally take place automatically, thus without any action by the driver. If, for example, the subscriber 4 had suffered a traffic

accident, then the driver in some circumstances might not even be capable of issuing messages by his own action.

The subscribers 6 ascertain their own position, for example by signal processing based on the global positioning system (GPS), and their spacing from the subscriber 4. The message from the subscriber 4 inclusive of his global position is passed on by the subscribers 6 after a predetermined waiting time  $t$ , which decreases with increasing spacing  $d$  between the subscribers 4 and 6, at an instant  $t_2$ , wherein  $t_2$  is greater than  $t_1$ , to further subscribers 8 (see Fig. 2). The message is in this example passed on by the subscriber 6 only when he has received the message for the first time. An unnecessary build-up of radio connections between the subscribers 4 to 12 is thus avoided.

Since  $t_2$  depends on the waiting time  $t$  and thereby on the distance between the subscribers, the case can occur that subscribers 6 in the vicinity of subscriber 4 have not yet dispatched the message at the instant  $t_2$ . The neighbouring subscribers 6 send the message to further subscribers 8 only at an instant  $t_3$ , wherein  $t_3$  is greater than  $t_2$  (see Fig. 3).

In addition, the option can be given that the subscribers 6 to 10 as receivers of the message from the first subscriber 4 decide about their affiliation with the target region 20 with the aid of a decision function. A geometric affiliation with the target region 20 is in some circumstances not adequate by itself, so that at least one further decision function may need to be drawn on for ascertaining the target region affiliation.

The exponential falling of the waiting time  $t$  in dependence on the distance  $d$  between two subscribers 4 to 10, in particular between the first subscriber 4 and second subscribers 6, is illustrated in the Fig. 4. It is thus ensured that subscribers 6 to 10 at the edge of the target region are preferentially envisaged for a rapid passing-on of the message of the first subscriber 4, whereby a rapid and effective dissemination of the message of the first subscriber 4 is provided. However, other functional relationships of the waiting time  $t$  on the distance  $d$  can be used in dependence on the scenario. In particular, different functional relationships can also be used within the partial network.

The message is passed on from subscribers to other subscribers in the radio communications network until all subscribers 6 to 12 have received the message. In a

further example, the message is provided with a counter, which indicates the number of transmissions of the message that have been made, the message then being passed on until a preset value for the counter state is reached.

A method exemplifying the invention ensures an optimum dissemination of messages, in particular of short messages, data packets and status reports, in the radio communications network 2.

CLAIMS

1. A method of disseminating a message in an incomplete radio communications network with a variable number of subscribers each having equipment for message transmission and reception and determination of position, comprising the steps of ascertaining by the respective equipment the positions of subscribers receiving a message and distances of those subscribers from the subscriber transmitting the message and transmitting on the message by the respective equipment together with the respectively ascertained position to further subscribers after a predetermined waiting time which decreases monotonically with increasing ascertained distance.
2. A method as claimed in claim 1, wherein the step of transmitting on the message is carried out only after first reception thereof.
3. A method as claimed in claim 1 or claim 2, wherein the message includes a geometric description of an intended region for reception of the message.
4. A method as claimed in claim 3, wherein the step of transmitting on the message is carried out only by subscribers of which the respective equipment ascertains affiliation with the region by way of a local decision function.
5. A method as claimed in any one of the preceding claims, wherein the message is provided with counting means for counting onward transmissions of the message and the step of transmitting is repeated until attainment of a predetermined count value by the counting means.
6. A method as claimed in any one of the preceding claims, wherein the waiting time decreases exponentially with increasing distance between the communicating subscribers.
7. A method as claimed in any one of the preceding claims, wherein the message includes an indication of the position of an event.
8. A method as claimed in any one of the preceding claims, wherein the step of ascertaining comprises determining positions by means of a global positioning system.

9. A method as claimed in any one of the preceding claims, wherein the equipment of each subscriber comprises an omnidirectional transmitter for transmission of the message.
10. A method as claimed in claim 1 and substantially as hereinbefore described with reference to the accompanying drawings.
11. A radio communications network comprising respective equipment for message transmission and reception and determination of position accompanying each of a variable number of subscribers, wherein the equipment accompanying each subscriber comprises ascertaining means for ascertaining the position of the subscriber and distance from a subscriber transmitting a message received by that equipment and transmission means for transmitting on the message together with the ascertained position to further subscribers after a predetermined waiting time which decreases monotonically with increasing ascertained distance.
12. A network as claimed in claim 11, wherein the transmission means is operable to transmit the message on only after first reception thereof.
13. A network as claimed in claim 11 or claim 12, wherein the message includes a geometric description of an intended region for reception of the message.
14. A network as claimed in claim 13, wherein the ascertaining means is operable to ascertain affiliation with the region by way of a local decision function and the transmission means is operable to transmit the message on only if such affiliation is ascertained.
15. A network as claimed in any one of claims 11 to 14, wherein the message is provided with counting means for counting onward transmissions of the message and the transmission means is operable to transmit the message on only if the instantaneous count value of the counting means is less than a predetermined count value.
16. A network as claimed in any one of claims 11 to 15, wherein the waiting time decreases exponentially with increasing distance between the communicating subscribers.
17. A network as claimed in any one of claims 11 to 16, wherein the message includes an indication of the position of an event.

18. A network as claimed in any one of claims 11 to 17, wherein the ascertaining means is operable to determine position by means of a global positioning system.

19. A network as claimed in any one of claims 11 to 18, wherein the transmission means comprises an omnidirectional transmitter.

20. A radio communications network substantially as hereinbefore described with reference to the accompanying drawings.



Application No: GB 9924504.5  
Claims searched: 1-20

- 11 -

Examiner: John Betts  
Date of search: 7 April 2000

## Patents Act 1977 Search Report under Section 17

### Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:  
UK Cl (Ed.R): H4L (LDRRX, LDRRS, LDRS, LDRX)  
Int Cl (Ed.7): H04B 7/14 7/15 7/155 7/185 7/195 H04L 12/56 12/58  
Other: On-line: WPI, EPODOC, JAPIO

### Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	US5481532 (Gen Elect)	
A	WPI abstract accession No. 1998-373533 & JP01-0150402 A (NEC) 3.9.98 se abstract	

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